this gave 15 lbs. weight of opium, and realised readily *forty-two* shillings per pound in Melbourne.* The want of assistance caused the remaining portion of the plants to be worked over hurriedly. One product was entirely neglected, namely, the collection of the seed; this, on expression, yields an oil useful in culinary purposes; also, for paints, being a drying oil, and for soaps, being soft and lubricating.

We have here another instance of a valuable product being obtained from off Victorian soil, and also, as in this case, where the question of carriage is concerned, the locale being in the mountain ranges, the cultivation of such vegetation would prove of great service to the mountaineers, being small in bulk, nil in carriage, and of high marketable value.

Art. XIII.—*On Hydrogenium.* By Geo. Foord, Esq.

[A popular notice, read at the Society's Annual Conversazione on the 8th July, 1870.]

By the kindness of Colonel Ward, R.E., I have the pleasure of showing an object which will doubtless prove of considerable interest to both visitors and members. It is a medal presented to Colonel Ward by Dr. Thos. Graham, the late Master of the Mint; and as coming from Graham's hands it is a memento of one of Great Britain's greatest physical philosophers. This, however, is only a portion of the interest resident in this little metallic disc, for it is also a tangible illustration of the very last of the life-long series of Graham's remarkable discoveries.

It is struck in an alloy of two rare metals: of palladium, a scarce metal of the platinum group, discovered by our countryman Wollaston, and of *hydrogenium*, or consolidated metallized hydrogen gas, which it was the last triumph of Dr. Graham's almost alchymical powers to transmute and chain down into the form of a metallic alloy with palladium.

It has been often maintained on chemical grounds that hydrogen gas is the vapour of a highly volatile metal, (these are Graham's own words); and hydrogen is equivalent to a metal in all its chemical relations. It replaces metals in one class of chemical changes, and it is replaced in its

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* Opium imported into Victoria bears a duty of 10s. per lb.

combinations by metals in another class of changes. By elevation of temperature all metals can be reduced to the fluid condition, and many are easily converted into invisible vapours. Even silver has been distilled, as water or spirit is distilled, although at a much higher temperature. Mercury is an instance of a metal fluid at common temperatures, but which can be frozen into a solid ; and there is an alloy of sodium and potassium which is also a fluid under normal conditions. Why then should we not have a metal which is gaseous under ordinary circumstances? There appears to be no valid reason ; but until Dr. Graham showed us this alloy of palladium and the consolidated hydrogen, we have never been able to catch a glimpse of hydrogen in either the liquid or solid form. Many gases liquify under intense pressure, and become even solid when the combined effects of both pressure and cold are employed ; but hydrogen has resisted every attempt to squeeze it into a liquid by pressure from without ; and it was not until Graham employed force in a different direction that any positive result of the compression of hydrogen was obtained.

Graham's results were obtained by making palladium the negative pole or cathode of a voltaic battery, decomposing water. In the arrangement, the hydrogen, one of the constituents of the resolved water, is set free in contact with the palladium, and as the latter has an affinity for the hydrogen, besides other physical peculiarities favourable to the fixation of the gas, the hydrogen, instead of rising in bubbles and escaping through the fluid, passes into the palladium. The hydrogen does not pass into the pores of the metal, if we understand the word pore in its everyday sense. It does not pass into any crevices or tubular openings into which moisture could enter, but it penetrates in the most intimate way the substance of the palladium, a metal denser than steel, having a specific gravity of 12·38, in fact, more than half as heavy again as cast-steel. The hydrogen passes into the palladium much as carbon is carried into the substance, between the atoms, of iron during the process of steel-making by cementation. The hydrogen passes in and is compressed, not by a pressure from without, but by an attractive force exerted from within. By this force the hydrogen is drawn to the innermost parts of the plate of palladium, and it is compressed and solidified into what shows strong evidence of being a true alloy of hydrogenium, and whose white metallic aspect is due alike to the hydrogenium and the palladium: it is compressed into a space something less than the eight thousandth part of that which it occupied as a gas, say at a pressure of over eight thousand atmospheres, or of 123810 lbs. per inch, or over 55 tons per inch.

In this case we may, as I have said, set altogether aside the idea of visible cavities or pores in the palladium, such as fluids might pass through, as through a sieve or grating; for the chemist is cognisant of abundance of interspace between the atoms of matter, spaces quite invisible to the eye, even when aided by the most powerful microscopes, but not less real on that account. And notwithstanding all that is understood concerning the impenetrability of matter, there appears to be quite an open road in the structure of even the most dense solids, through which the atoms or molecules of other kinds of matter can enter whenever their chemical affinities dispose them for this kind of interpenetration.

In this way 23 parts of sodium, which is quite a solid metal can absorb 24 parts of oxygen and 6 parts of carbon; considerably more than its own weight of these substances, and the resulting carbonate of sodium occupies *less* space than the original metal. Here is a sort of stereo-diagram intended to show the composition of the chloride of sodium contained in a gallon of sea-water; it represents a sphere of sodium of something under 1.9 inches diameter, also a sphere of chlorine gas of over $14\frac{3}{4}$ inches diameter. When, then, this relatively enormous atmosphere of chlorine, weighing about one and a-half times the weight of the sodium sphere is absorbed by the latter, the resulting sphere of common salt (of rock salt let us say) is but little larger than the original metallic sodium, so great is the power of condensation due to the affinity of the sodium for the chlorine, and so facile is the interpenetration of these constituent elements of the rock salt. But in this latter example, although the condensation is so great, there is, you will observe, a slight increase of bulk in the product over that of the original metallic sodium. The salt sphere measures nearly 2 inches diameter.

The condensation of the hydrogen into the substance of the palladium is also of the character of a chemical combination, but the compound formed is an alloy of two metals instead of a haloid salt. An enormous condensation takes place, and there is also, as in the former example of the formation of common salt, a measurable increase in the size and in the weight of the product. Graham has investigated these changes with such precision and minuteness as to show exactly what takes place. The palladium can absorb into its substance not less than 936 times its volume of hydrogen gas; that is to say, a small disc of the solid palladium of the diameter of this tube *(showing a glass tube over three feet in length)*, and $\frac{1}{25}$th of an inch thick, something nearly approaching the size of this little gem of a medal, would condense within its atoms the whole contents of this tube of hydrogen gas. If we regard the little disc as a piston closely fitting the tube, and if we regard this condensation of the hydrogen as the result of a pressure exerted from without, it would require a force equal to more than eight thousand atmospheres, a pressure of over 55 tons on the inch, to force this piston down in the tube until the palladium and condensed hydrogen together occupied the same bulk as they do in the alloy, by virtue of the force of attraction exerted from within.

When the combination of the palladium and hydrogenium is effected, the resulting alloy is of larger bulk than a very great increase of temperature of the palladium itself would occasion; but the palladium itself in the alloy is actually squeezed into a smaller space at the time of combination. This is shown by its occupying less than its original space, if the hydrogenium be distilled out of it, and by certain experiments, the results of which prove that this diminution of bulk does not take place at the time of the expulsion of the hydrogenium.

That the combination is of the nature of an alloy is deduced from measurements of its tenacity and electrical conductivity, both very near to those of pure palladium, and, which is very remarkable, by the hydrogenium in the alloy proving measurably a magnetic metal. The two constituents stand in atomic proportions, and the solidified hydrogen, the hydrogenium, has chemical properties differing from those of hydrogen gas, differing very much as the properties of ozone do from those of oxygen. From a solution of corrosive sublimate, the alloy of hydrogenium and palladium precipitates mercury and calomel, a change which hydrogen itself is quite incapable of effecting. A mixture of hydrogen and chlorine gas remains permanently unchanged as long as it is kept in the dark; but exposed to the influence of daylight these gases combine; but hydrogenium combines with chlorine in the dark. Hydrogenium reduces persalts to the state of the protosalts of iron. It converts red prussiate into yellow prussiate of potassium, and it has generally considerable deoxidizing power.

The results of Dr. Graham's precise experiments allow of a computation of the specific gravity of hydrogenium as it exists in the alloy. According to his latest figures, its gravity may be taken at ·7; it is therefore of greater specific gravity than lithium (taken at ·59); indeed the collective evidence is so much in favour of regarding the combination as an alloy, that the case may be regarded as parallel to that of the fluorides. We know fluorine very well in its combinations; but we cannot yet properly succeed in isolating fluorine from fluor spar or any other of its compounds, so as to obtain a private interview with it, and in the same way we now know hydrogenium as a metal alloyed with palladium, although we cannot yet isolate little silvery globules of the hydrogenium itself.

Art. XIV.—*On the Melbourne Great Telescope.* By A. Le Sueur, Esq.

[Read 11th July, 1870.]

In this paper Mr. Le Sueur showed that the disparagement of the Melbourne Great Telescope by Mr. Severn in his late paper was unfounded, and arose from ignorance of the subject.

Art. XV.—*On Railway Working Expenses in Victoria.* By F. C. Christy, Esq., C.E.

[Read 15th August, 1870.]

In this paper Mr. Christy adduced evidence to show that the Victorian Government Railways were worked at half the cost of working American lines, and from 13 to 30 per cent. lower than English lines. This he attributed to the superiority of the road bed, of the rolling stock, of the climate, and to the excellent system of repairing promptly and economically.